1. Title of the Invention

MANUFACTURING METHOD OF DISPLAY DEVICE

2. Scope of a Claim

(1) A manufacturing method of a display device wherein a display device is manufactured by overlapping two electrode plates through a seal material to make electrode surfaces face each other, and hardening the seal material, characterized in that the process of hardening the seal material is conducted under reduced pressure.

3. Detailed Description of the Invention

The present invention relates to a manufacturing method of a display device.

There are a liquid crystal display device, an electrochromic display device, and an electrophoresis display device as display devices. And there is a display device wherein electrode plates having electrodes formed on a glass or a plastic board are installed to make their electrode surfaces face each other, the electrode plates are overlapped and sealed though a seal material, and an electrooptic liquid like a liquid crystal is enveloped inside thereof.

Among these display devices, a liquid crystal display device is the most frequently used one. For example, as illustrated in Fig. 1, the liquid display device comprises two electrode plates (1),(2) having transparent electrodes (4A),(4B) and a seal material (3), and a liquid crystal (5) is enveloped in the inside thereof.

In this liquid crystal display device, respective electrode plates (1),(2) are formed, and a seal material is given to at least one electrode plate and is hardened by pressurization.

Figs. 2 and 3 are sectional illustrations of the device for making a pressurized seal. In Fig. 2, reference number (6) is a table for pressing, reference numbers (7A),(7B) are buffer materials for giving power evenly, reference number (8) is an air cylinder for giving power, reference numbers (9A),(9B) are heaters, reference number (10) is a mold for transmitting the power of the air cylinder to a cell (11).

Fig. 3 illustrates a device for pressing a cell by use of a layer (12). Reference number (12) is a film for transmitting pressure to the cell (11), which gives pressure to the cell by enveloping compressed gas in a space between the mold (13), and is connected through a pipe to a compressed gas source in the upper portion of the drawing, which is not illustrated.

In this case, the lower table (6) is the same as that of Fig. 2, which has a heater (9B), and a buffer material (7B) installed in the upper surface. Although not illustrated in this drawing, an apparatus to fix the upper and lower position of the upper mold (13) may be installed.

In the cell of the liquid crystal display device based on the above apparatus, a couple of electrode plates having transparent electrodes installed on are arranged to make their electrode surfaces face each other, and a seal material is printed on at least one electrode plate by a screen printing.

The embodiment of Fig. 2 or Fig. 3 is an apparatus used in a case where a theremosetting seal material is used. A cell (1) is arranged on a buffer material (7B) on a lower mold (6), an upper mold (10) is pushed and pressurized by an air cylinder (8), or a film (12) is pushed and pressurized by compressed gas, and a seal material is hardened by being heated by heaters (9A),(9B).

Also, a room temperature setting seal material is not heated, but only is pressurized in a room temperature, and an ultraviolet ray setting seal material is hardened by being pressurized and irradiated by ultraviolet rays.

When a cell is sealed by use of the conventional apparatus for hardening a seal material as described above, water and gas discharged from the seal material are adsorbed to the surface of the electrode plate of the cell, to which a liquid crystal is injected. This adversely affects the liquid crystal, and reduces durability of the display device, after a liquid crystal display device is completed by injecting and sealing up the liquid crystal therein.

The present invention, which is provided to remove the above defects, is a manufacturing method of a display device wherein a display device is manufactured by overlapping two electrode plates through a seal material to make their electrode surfaces face each other, and hardening the seal material, characterized in that the process of hardening the seal material is conducted under reduced pressure.

According to the manufacturing method of the present invention, since the process of hardening the seal material is conducted under reduced pressure, the gas produced by the hardening of the seal material is promptly exhausted outward from the cell, and is hardly attached to the electrode plate, which increases durability of the display device.

The manufacturing method of the present invention will be explained based on a desirable apparatus with reference to the drawing.

Fig. 4 is a sectional view of a desirable apparatus for hardening a seal material used in the present invention.

As a cell (14) of the display device installed in this apparatus, there are said cell of a liquid crystal display device, a cell of an electrochromic display device and a cell of

an electrophoresis display device. There are liquid display substances, for example, a liquid crystal, pyrogen, or a display accessory substance, for example, a propylene carbonate solution wherein a lithium perchlorate is melted for the coloring or fading of the WO_3 layer, between the two electrode plates. The present invention will be explained based on the embodiment of a liquid crystal display device on below.

Generally, the two electrode plates of the cell of the liquid display device are transparent boards made of a glass or a plastic, having a transparent electrode formed thereon. However, it is possible to make one of the electrodes be an opaque board as a repeller, or a semiconductor board, to use a multilayered cell, wherein five or more boards are installed, and also to use two-layered electrodes. However, this embodiment shows the simplest transparent board, wherein one-layered transparent electrode is installed on one surface.

These electrode plates are sealed to make their electrode surface face each other. A heat-setting, room temperature setting or a ultraviolet ray setting seal material is provided on at least one electrode plate by a screen printing. Of course, a spacer for regulating the gap of a cell like a glass fiber or an alumina particle can be arranged in this seal material. And, the seal material can be provided not only to the circumference of the cell, but within the display surface in the shape of spots or a line.

Especially, the present invention is useful when forming a part, in which a liquid crystal is not filled, within the display surface of the cell by a seal within the display surface. An exclusive large-sized cell has many parts that does not display even within the display surface. Also, it can be thought of to form a closed space, into which a liquid crystal is prevented from being put by a seal material, within the display

surface, in order to maintain a constant gap of the cell and to reduce the amount of the filled liquid crystal.

When such a closed space is formed and the cell is sealed in atmospheric pressure, after the seal material contacts the two electrode plates, the air trapped inside cannot come outside. Therefore, a seal material is not pushed in such parts, and thereby the gap of the cell is broadened, and defects like color mottles are incurred.

The printing height of the seal material is increased up to more than two times of the gap of the cell after sealing up. When the seal material is pushed by pressurization, the height of the seal material is reduced to the height regulated by the spacer of a glass fiber or an alumina particle that is generally mixed in the seal material, while the width of the seal material is increased. Where two electrode plates are closely adhered to each other and the seal material is not pushed sufficiently, the cell expands.

Moreover, in a liquid crystal cell, the gap of the cell is controlled to the degree of $\pm 1\mu$, generally, and the unevenness in the gap of the cell causes a user to have difficulty in watching due to the color mottles.

However, according to the present invention, a cell, wherein such a closed space is formed within a display surface with a seal material, can be easily pushed and thereby maintain a constant gap of the cell, because the cell is sealed under reduced pressure.

Also, such a cell having a closed space can be used not only in a large-sized cell such as an exclusive instrument panel, as mentioned above, but also in a small-sized cell such as a digital clock, to which hands are attached, by forming a double-sided seal on

the part where the hole for the hands is to be formed, and forming a hole for the hands after sealing.

A well-known alignment treatment is formed on the surface within the electrode plate by forming an overcoat of SiO_2, Al_2O_3 and polyimide, obliquely deposing SiO_2, and Al_2O_3, and rubbing.

This liquid crystal cell (14) is arranged on a mold (16) having a heater for heating laid therein, through a buffer material (17). A plastic and expansible partition layer (18) and an upper mold (19) are arranged on the mold (10). A heat-resistant silicon rubber sheet or a rubber sheet including a glass fiber is used as this partition layer, which may be connected to, or may be separated from the mold (19).

The mold (16) is connected to a suction pump (17), and a valve (20) and a valve for canceling decompression (21) are installed between the mold (16) and the suction pump(17). A valve (22) and a valve for canceling decompression (25) are installed between a mold (19) and a suction pump.

That is, a liquid crystal cell (14) is arranged on the lower mold (16), a plastic partition layer (18) is arranged thereon, and the upper mold (18) is arranged thereon again. The lower space formed by the lower mold and the partition layer and the upper space (25) formed by the upper mold and the partition layer are made to be capable of being decompressed. Also, the upper mold presses the partition layer to the upper surface of the side wall of the lower mold.

The operation of the present invention will be explained.

A liquid crystal cell is arranged, and a partition layer (18) and a mold (19) are arranged thereon. The pressure of the lower space (24) is reduced to -0,2 ~ -1kg/cm^2 by closing a valve (21), opening a pulse(20), and exhausting the lower space by the

suction pump (17). The gases like oxygen and moisture attached to the electrode surface of the liquid crystal cell are discharged in this process. Then, the seal material is hardened by being heated to the temperature of 100 ~ 200°C by a heater, or being irradiated by the irradiation source of ultraviolet rays. When the seal material is hardened, gases may be generated from the seal material, but are discharged outside the cell, without being attached to the electrode surface, because the cell is under reduced pressure.

Here, it is possible to enforce the pressure by providing a pressurizing gas into the upper space (25), if necessary.

Also, it is possible to use only the partition layer (18) and the lower mold (16), without using the upper mold (19).

Also, it takes time to heat the seal material, and therefore it is desirable to pre-heat the mold before arranging the liquid crystal cell.

After the seal is hardened, the decompression of the lower space (24) is removed, and the lower space gets to have atmospheric pressure by closing the valve (20), opening the valve (21) and providing a dry air and a N_2 gas thereto.

Also, the valve (20) may be closed in a state where the space (24) is under a predetermined amount of reduced pressure, and then may stop the suction pump, or continue or intermit decompression.

Also, when the apparatus of Fig. 4 is used, after the cell is decompressed by opening the valve (20),(22) and closing the valve (21),(23) and the upper and lower spaces (24),(25) are made to be under reduced pressure, the pressure of the liquid crystal cell may be adjusted to be a desired one by changing the decompression degree of the upper space by closing the valve (22) and opening the valve (23) a little bit.

When the apparatus by use of a partition layer (18) and a mold (16) like the one in Fig. 4 is used, it is not necessary to change a mold (10) according to the shape and size of a cell like the apparatus of Fig. 2. Also, the apparatus of Fig. 4 does not need a tool for generating a large amount of pressure in a large-sized cell and a tool for receiving and supporting the tool for generating a large amount of pressure. The suction pump is enough for the apparatus of Fig. 4, for which it is easy to evenly provide force.

Also, when compared with the apparatus of Fig. 3, the apparatus of Fig. 4 is better, because it does not need to use pressurized gas, and therefore the tools thereof are simple.

After a liquid crystal cell is formed in this manner, liquid crystal materials, which include, for example, a nematic liquid crystal, choresteric liquid crystal and, if necessary, a two-colored dye and a optically active material added thereto, are injected into the cell, and the inlet of the cell is sealed up.

Then, a polarizer, a color polarizer, a reflector, a color filter, a quarter-wave plate, and a light guide plate are stacked, a nonglare treatment is made thereon, and letters, figures and diagrams are printed thereon to form a liquid crystal display element.

Embodiment

Rubbing treatment is made on the surface of the glass board having a transparent electrode formed thereon. A thermosetting epoxy resin is printed on one board by a screen printing. Two boards are arranged to make their electrode surfaces face each other, and are arranged through a butter material (26) on the lower mold (16), whose temperature is raised up to 150°C, by use of the apparatus of Fig. 4.

Then, a silicon rubber sheet having a thickness of 1mm is arranged thereon as a partition layer, is pressed to the upper surface of the side wall of the mold (16) by a pushing frame corresponding to a mold (19). The valve (21) is closed, and the valve (20) is opened, and thereby the space (24) is decompressed and maintained to have pressure of -0.6kg/cm^2 for 10 minutes. Then, the valve (20) is closed, and the valve (21) is opened to make the space (24) to have atmospheric pressure by introducing N_2 gas. Then, a partition layer and a pushing frame are removed, and a liquid crystal cell is extracted.

Therefore, a sealing condition equal to the seal condition obtained by the conventional pressure seal method, in which the seal material of this liquid crystal cell expands very uniformly, and the gap of the cell is maintained almost uniformly, can be obtained.

In the above embodiment, only the cases of a liquid crystal cell and a group of liquid crystal cells are explained. However, the present invention can be applied to an electrochromic cell and an electrophoresis cell. Also, the present invention can be used in the conventional mass-production method wherein a plurality of cells are formed on a couple of electrode plates simultaneously, and then are cut off to be separated from each other, and a manufacturing method of a multilayered cell wherein two or more layers of a liquid crystal are formed on three or more pieces of electrode plates. Also, the present invention can be applied in various ways.

4. Brief Explanation of the Drawings

Fig. 1 is a sectional view of a liquid crystal display device.

Figs. 2 and 3 are sectional views of the conventional pressurizing apparatus for hardening a seal material.

Fig. 4 is a sectional view of a pressurizing apparatus suitable for the hardening of a seal material of the present invention.

Mold 16,19

Pressurizing pump 17

Partition layer 18

Valve 20,21,22,23